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PROCYON MISSION: A MICRO-SPACECRAFT TO AN ASTEROID

Abstract

PROCYON (PRoximate Object Close flYby with Optical Navigation) is a 50kg-class micro-spacecraft mainly developed by the University of Tokyo and the Japan Aerospace Exploration Agency (JAXA), to be launched in an Earth resonant trajectory at the end of 2014 as a secondary payload with Hayabusa 2. The mission objective is to demonstrate micro-spacecraft bus technology for deep space exploration and proximity flyby to asteroids performing optical measurements. This paper presents the mission asteroid selection, trajectory design and close approach operations. The mission design of such a small scale spacecraft possesses many challenges, such as, the fact that the thrust of the ion engine is 0.3 mN that is three orders of magnitudes less than a typical low-thrust mission; the flyby of the asteroid will rely solely on optical navigation that depends on the lighting condition on the approach; the low specific impulse (25 seconds) of the cold gas engine used for correction maneuver during the asteroid flyby and unloading the reaction wheels; strict requirements on the power and thermal conditions and communication link with the ground station due to the small mass budget; small fuel mass available for trajectory correction maneuvers; and, finally, the launch trajectory for the spacecraft is restricted by the Hayabusa 2 trajectory. Therefore, the mission design segments have to be optimized altogether. For example, low-thrust interplanetary maneuver helps to decrease the fuel amount for trajectory correction maneuver in the proximity of the asteroid flyby. The resonant trajectory allows the spacecraft to cruise back to Earth allowing an Earth

gravity assist maneuver that increases the number of candidate asteroids. In this way, the trajectory sequence for PROCYON is as follows: 1) EDVEGA phase (Earth to Earth), 2) Transfer phase (Earth to Asteroid), and 3) Proximity Asteroid Flyby phase. In phases 1 and 2, the spacecraft uses radio navigation for determining the trajectory and miniature ion propulsion system for low-thrust transfer. However, at around 10 km proximity flyby it requires a more accurate orbit determination, optical navigation, which allows the spacecraft to determine precise trajectory relative to the asteroid in phase 3. The optical navigation can be effectively used less than a week before the close approach; this short time available for the guidance requires a high thrust propulsion system. Hence, it was developed an ion engine and Xenon cold gas jet combined system, solving not only this mission requirement but also sizing requirement for micro-spacecraft.